U.S. Department of Agriculture Agricultural Research Service Vol. 33, No. 2, February 1985

Agricultural Research

Forage Legumes—Untapped Resource

Robert F. Barnes is an internationally recognized agronomist with USDA's Agricultural Research Service. His research specialty has been the methodology of evaluating nutritional properties of forages. In 1984, he helped organize a multination workshop entitled "Forage Legumes for Energy-Efficient Animal Production" at Palmerston North, New Zealand. Thirty-eight scientists from Australia, New Zealand, and the United States participated in the meeting. The following interview points up the value of forage legumes in producing animal protein foods for human nutrition.

Ag. Res. What was the meeting in New Zealand about? What are forage legumes?

Barnes. Most everyone's heard of clover and alfalfa. A lot of people probably haven't heard of trefoil, sainfoin, or lespedeza. There are thousands of species of legumes, all botanically related to the beans and peas we eat. Many of us believe that legumes have a potentially greater role in the world's grasslands. We met to assess the situation and discuss what should be done to increase the use of legumes. Like our country, Australia and New Zealand are major livestock producers, and we have many things in common.

Ag. Res. "Potentially greater role"? What's so important about these plants?

Barnes. The key word is nitrogen—an essential building block for both plants and animals. Nitrogen fertilizer has become an increasingly costly agricultural input. Unlike grass, most legumes, with the help of certain soil-living bacteria, can manufacture their own nitrogen nutrients from the nitrogen in the air. Increasing the use of legumes in pasture has the potential for reducing dependence on nitrogen fertilizer. Also, generally speaking, legumes are more nutritious for livestock than grass is.

Ag. Res. Why don't you just recommend seeding or planting more grassland with legumes?

Barnes. I wish it were that easy. Although various forage legumes are being successfully used in farming systems in some places, in much of the United States and the world they have not been successful. At scientific meetings, we talk about their lack of persistence, which means they are hard to get going and keep going.

Ag. Res. Why?

Barnes. Many reasons. They are attacked by more plagues than Biblical Egypt was—insects, diseases, and nematodes too numerous to mention. They are particular about soil and climate. They can be killed off easily by grazing. And these factors interact—it's not a question of dealing with an isolated problem or two. The problems are especially severe in the hot, humid areas of the world.

Ag. Res. They sound hopeless.

Barnes. Oh, no. Research deals with problems, not successes. Forage legumes have too much potential to be ignored. Think, for example, how all kinds of plants have been improved through selective breeding.

Ag. Res. Is breeding improved forage legumes the answer?

Barnes. It's part of the answer, and there have already been many successes. At the end of the Palmerston meeting, we made several recommendations for collaborative projects between Australia, New Zealand, and the United States. One was for plant development, both by conventional breeding and, as the technology is perfected, by genetic engineering. Another closely related recommendation was for plant exploration, collection, and evaluation. I think the potential of the legume gene pool has hardly been touched.

Ag. Res. Will anything come of these recommendations?

Barnes. We appointed coordinators for the projects in each country represented. These people are setting up communications networks among scientists working on similar problems. We hope this networking will improve research planning and lead to faster, more easily obtained practical results. None of the large agricultural problems we face today will be solved by individuals working alone.

Ag. Res. Will you briefly explain the importance of livestock forage crops and how they fit into the whole agricultural picture?

Barnes. I'll try. We need to remember that only a small fraction of the planet is suitable for very intensive cultivation, whereas much more of it is suitable for some level of grazing. Even as we talk, land that is better suited for livestock production is being placed under cultivation around the world, and other grassland is being overgrazed. Experience should have taught us what the long-term consequences of such misuse can lead to: destruction of our soil and water resources—the foundation of all agricultural enterprise. Properly managed grasslands, on the other hand, are soil and water conservers and soil builders. We need to remember also that the increasing world population is going to compete for cereal grains that are now being fed to livestock. Greater reliance on grasslands will become a necessity to produce the meat, milk, hides, fibers, and animal byproducts that people are going to continue to want and need. These are the most important reasons, I think, that we should develop and manage our grasslands.

—Interviewer, **David Pyrah**, New Orleans, La.

Agricultural Research

COVER: At the Insect Physiology Laboratory, Beltsville, MD, technician Thelma Golden feeds artificial diet to tobacco hornworm larvae. At this and over 60 other laboratories around the country, hundreds of millions of insects of many species are reared each year in search for alternatives to chemical pesticides and the creation of pest-resistent crops. (1283X1662-3)

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DEPARTMENTS

Agricultural Research
Vol. 33, No. 2
February 1985

Editor: Lloyd E. McLaughlin
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Agricultural Research is published 10 times per year by the Agricultural Research Service (ARS), U.S. Department of Agriculture, Washington, DC 20250. The Secretary of Agriculture has determined that the publication of this periodical is necessary in the transaction of the public business required by law of this Department. Use of funds for printing this periodical has been approved by the Director of the Office of Management and Budget through March 31, 1987. Send subscription orders to Superintendent of Documents, Government Printing Office, Washington, DC 20402. Information in this magazine is public property and may be reprinted without permission. Prints of photos are available to mass media; please order by month and photo number.

Magazine inquiries should be addressed to: The Editor, Information Staff, Rm. 318, Bldg. 005, Beltsville Agricultural Research Center-West, Beltsville, MD 20705. Telephone (301) 344-3280. When writing to request address changes or deletions, please include a recent address label.

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Common Weed Suspect in Cattle Abortions

An inconspicuous weed is a prime suspect in spring abortions that strike cattle in some southern states.

A team of four scientists with ARS and Texas A&M University has identified narrowleaf sumpweed *(Iva angustifolia)* as "almost certainly the cause of bovine abortion" in several herds in Louisiana and Texas. The weed also grows in Arkansas and Oklahoma.

Although the scientists have not produced abortions in cattle experimentally, they have shown that the weed causes changes in the reproductive systems of cattle and that it causes abortions in rabbits. They expect to demonstrate the cause-and-effect relationship in cattle.

The team includes Michael J. Murphy, John Reagor, and Allen C. Ray of the University's Veterinary medical Diagnostic Laboratory and Loyd D. Rowe of ARS's Veterinary Toxicology and Entomology Research Laboratory. All are based at College Station, Tex.

Narrowleaf sumpweed is an unpalatable annual that cattle would normally avoid. It grows from 2 to 4 feet tall and has many branches and long, narrow, slightly saw-toothed leaves. It produces small green flowers, which may be white or yellow at different stages of maturity. In areas with 35 or more inches of rainfall per year, the weed tends to be located in well-drained soil. In locations with low rainfall, it grows in drainage ditches, creekbeds, and on disturbed land. According to the scientists, it is likely to be most toxic in its early, rapidly growing, seedling stage.

The weed became the suspect when a herd of cattle on a Louisiana ranch was reported to have an uncommonly high rate of spring abortions. The calving rate in the herd had dropped from 70 to 50 percent. The problem coincided with the greening of a particular pasture in March and April. This pasture was covered with a seedling later identified as narrowleaf sumpweed and was heavily grazed. When the Louisiana rancher delayed the calving season 2 months to prevent cattle from grazing on the young seedlings, the rate of abortion dropped from 40 to 10 percent.

Since then, two other instances of spring abortion have been linked with the unavoidable consumption of the sumpweed seedling in central Texas.—**Bennett Carriere**, New Orleans, La.

Loyd D. Rowe is located at the Veterinary Toxicology and Entomology Research Laboratory, P.O. Drawer GE, College Station, TX 77841. ■

Better Crops Through Stress Survival

Progress in developing new, superior crop varieties could be dramatically accelerated if a new theory now being tested proves true.

The theory, conceived by ARS plant geneticist Devon L. Doney, Fargo, N. Dak., proposed that genetic differences can be magnified for swifter, easier selection if stress related to vigor rather than disease resistance is imposed on a plant.

Doney likens the situation to a pair of badly mismatched boxers. "If the ring is an acre in size, the less skilled fighter can survive longer by keeping a safe distance, but if the ring is only 12 feet square, the differences in their abilities will become evident much sooner."

Doney is testing his theory on sugarbeets. If it holds up, he estimates that breeding time for this crop could be cut in half. Improvements in sugar production once made over a period of 10 to 15 years could be realized in 5 to 7 years, he says. He emphasizes, however, that the theory applies only to plant vigor and does not necessarily relate to seed production.


(Photo by Grant Heilman)
Sugarbeet.

Doney grows beets in the greenhouse under standard conditions for about a month. He then trims the leaves and places the plants in total darkness, forcing them to grow new leaves without the benefit of photosynthesis. Under these conditions, the plants must rely on stored energy. Those plants that are the best photosynthesizers and store the most energy, or make the best use of their energy reserves, survive; the rest perish.

Through careful timing of the stress, Doney is able to target his tests for a 25 percent survival rate. Those plants left standing at the conclusion of a test are the top 25 percent of a given collection in the category of vigor.

Early indications are that Doney's theory will prove true and

will be a useful tool for sugarbeet breeders and possibly breeders of other crops as well.—**Lynn Yarris**, formerly at Oakland, Calif.

Devon L. Doney is located at the ARS Sugarbeet Research Unit, State University Station, Department of Agronomy, North Dakota State University, Fargo, ND 58102. ■

Great Plains Get a Better Break

A new hackberry tree may keep winds in the central and northern Great Plains from snatching away irreplaceable topsoil. Wind erosion is a problem on 35 million acres of the Great Plains.

Oahe, a Sioux word pronounced O-ah-he, is a medium-to-large tree developed as a windbreak at the Northern Great Plains Research Laboratory at Mandan, N. Dak., in cooperation with the Soil Conservation Service's (SCS) Plant Material Center at Bismarck.

According to its developer, Richard A. Cunningham, Oahe has a better rate of survival and growth than common hackberry and performs well on well-drained soil in farmstead plantings.

Oahe originally came from seed collected in 1937 from native hackberry growing along the Missouri River in South Dakota. Seedlings from the South Dakota collection were planted in a windbreak at North Dakota State University Experiment Station at Dickinson 2 years later and developed into trees that showed superior height, form, and survival. In 1958, 11 seedlings from these trees were planted at the ARS Mandan station. "All of the trees performed well," Cunningham says, "and their seed was used to grow seedlings for field trials."

In field tests in North Dakota with slight-to-moderate weed competition, survival rates ranged from 43 to 96 percent. In South Dakota tests, under clean-tilled conditions, Oahe averaged 94 percent survival.

Oahe is recommended for planting in the northern Great Plains area. It has not been tested in other areas. Both ARS and SCS will maintain breeder seed and foundation in stock.

"Producing new windbreak plant material is not easy or something we do quickly," Cunningham says. "We are severely limited in our choice of medium-to-tall tree species that are well adapted and long lived."

He and coworkers are now involved in a regional hackberry seed source test with SCS. "In this project, we will be collecting seed from native trees growing in nine states and one Canadian province, and we hope to establish at least one test plantation in each of the locations sampled," he says.

"Our goals are to identify the seed sources of hackberry best adapted for planting in the central and northern Great Plains and to assemble a gene pool for future selection and breeding."

In 1983, about 5.4 million acres were damaged by wind erosion, according to SCS figures.

About 101,000 miles of windbreaks have been planted in the Great Plains with trees such as green ash, Siberian elm, Russian olive, caragana, ponderosa pine, and Colorado blue spruce. "But the job is not complete," says Cunningham. "SCS estimates that we need 250,000 miles more."

Tree windbreaks are supplemented with perennial tall grass barriers, flax strips, stubble mulching, and minimum tillage. Recent research on supplemental plantings has produced Rodan western wheatgrass—a perennial tall, dense, sod-forming grass that does well on coarse-textured soils. Another tree barrier with promise is the Cardan green ash, a medium-sized tree that may grow to 50 feet on good soils.

Both Oahe hackberry and Cardan green ash are seen as replacements for Siberian elm, a once popular species that is now showing increased mortality from herbicides, disease, and winterkill.

Research geneticist Richard A. Cunningham with the Oahe hackberry tree. Now approximately 17½ feet tall, this windbreak tree developed for use in the Northern Great Plains area, will grow as high as 50 feet. (PN-7148)

ARS scientists are working to overcome the problems with Siberian elm as well as study other species with high potential such as bur oak, honey locust, juniper, poplars, lodgepole pine, and Scotch pine.—**Betty Solomon**, Peoria, Ill.

Richard A. Cunningham is located at the Northern Great Plains Research Laboratory, P.O. Box 459, Mandan, ND 58554. ■

Reducing Hidden Salt Makes Sense

Reduced-sodium frankfurters are manufactured for taste testing at the Food Science Laboratory, ERRC, by food scientist Richard Whiting (left) and student assistant Charles Kunsch. (PN-7145)

"Hotdogs, corned beef, potentially all processed meats could be made with 20 to 25 percent less sodium chloride—or table salt—without causing harmful effects," says food technologist Richard C. Whiting.

And recipes for commercial and homemade leavened breads could call for 50 percent less sodium chloride without appreciable loss in bread quality, says food technologist Eugene Guy.

Research-tested, low-salt meat and bread mixes are the results of a 2-year study by Whiting, Guy, and colleagues at the Eastern Regional Research Center in Philadelphia, Pa. The scientists are looking at ways to lower sodium levels in meat, dairy, and baked products without reducing shelf life or increasing the risk of food poisoning.

High dietary sodium has been frequently linked to high blood pressure, heart disease, kidney failure, and other health problems by nutritional and medical researchers, they say.

Americans eat five to seven times the actual human requirement for sodium, according to findings recently reported by J. Cecil Smith, chief of the Vitamin and Mineral Nutrition Laboratory at Beltsville, Md. Results of a 1-year study done by ARS and University of Maryland scientists at the Beltsville laboratory show that volunteers on self-selected diets averaged 3.4 grams of sodium per day. That is slightly more than the "safe and adequate" range suggested by the Food and Nutrition Board of the National Academy of Sciences, says Smith. The average human requirement for sodium is only 0.5 gram per day, he notes.

More than 30 percent of an American's intake of table salt comes from commercially processed foods, Whiting says. ARS studies show that perhaps 10 percent of the daily intake comes from meat products and that only three slices of bread can contribute another 10 percent.

Taste panels reported no flavor loss in breads made from doughs containing 1 percent table salt instead of

the average level of 2 percent in commercial breads.

Lower salt hotdogs compared well with conventional hotdogs in flavor, texture, and shelf life, says Whiting. The study also showed that proper refrigeration is more important in retarding the growth of microorganisms that cause spoilage (and can lead to food poisoning) than is the salt level.

An important finding in the yearlong nutrition study at Beltsville was that an increase of potassium in the diet can lower a person's diastolic blood pressure—apparently by increasing the amount of sodium excreted. Smith and colleagues reported in the December 1984 issue of the *American Journal of Clinical Nutrition* that their results support nutritionists' theory that the ratio of potassium to sodium in the diet is more important to blood pressure than the amount of each.

In support of recent recommendations by nutritionists, the Philadelphia scientists also conducted studies in which they substituted potassium chloride for sodium chloride in the meat and bread products.

Taste panels found no taste difference when up to 25 percent potassium chloride was substituted for sodium chloride in hotdog mixes. "A slight bitterness was detected above 25 percent, but some panel members got used to as much as a 50-percent substitution," Whiting says.

Guy reports similar taste-panel acceptance of bread made with up to 50 percent substitution of potassium for sodium. He says that dough mixing, leavening, and bakery cleanup are easier with lower sodium doughs.

Several laboratories at the Philadelphia center conduct experiments on foods and food products, often setting industry standards for processing safety and quality, says Whiting. He says that some meat-packing companies are already producing delicatessen products with lower salt or substituted potassium and that his research demonstrates the feasibility. "It isn't going to cause more spoilage or health hazards." Research on lower salt formulas for dairy products is now underway.

Whiting's and Guy's formulas for low-salt products are not patented and thus can be obtained without license. For information write to the scientists at the address below.—**Stephen Berberich**, Beltsville, Md.

Richard C. Whiting and Eugene J. Guy are located at the Eastern Regional Research Center, 600 E. Mermaid Lane, Philadelphia, PA 19118. ■

Winter Wheat Survives Despite Plowing

Chisel plowing to stop wind erosion in fields of young wheat seldom reduces yield, researchers report following a 5-year study of this emergency practice.

An average of about 6 million acres of the Great Plains have been chisel-plowed each of the last 14 years to control wind erosion, according to the Soil Conservation Service.

"Much of that land was in winter wheat," says Leon Lyles, ARS agricultural engineer, "and we needed to know what effect chiseling has on wheat yields."

In 5 years of tests at two sites, Lyles and John Tatarko, research assistant with the Kansas State University agronomy department, were surprised to find that wheat yields were significantly reduced by chiseling in only 1 year and at one location.

When vegetative cover is inadequate for wind-erosion control, the most common solution is emergency tillage, usually by narrow-point chisels to roughen the soil surface, Lyles says. Many farmers resist chiseling because they assume, quite logically, that yields will be hurt by the tillage activity.

"We conducted field experiments on a fine sandy loam soil at one site, and on a silty clay soil at another location, both in Finney County, Kans. We tilled some plots or test areas parallel to the wheat rows and some perpendicular to the rows," he said. "We also tested two chisel spacings, 30 and 60 inches, and tilled all of some plots and only half of the others in alternate strips."

In the 1 year that chiseling did depress yields, 1980, no rain occurred for 35 days after planting in September of 1979, and cold temperatures in November and December limited growth and encouraged early dormancy. When chiseling was done in March 1980, the wheat was hardly visible, consisting of single shoots about 1 inch tall. Plants did not survive in the tillage zones, and yields were reduced 27 to 56 percent. Apparently, soil thrown over small plants killed them. Tillage areas were also weed-infested at harvest time.

The results suggest that emergency tillage soon after emergence, before plants can make good top and root growth, would reduce yields, Lyles says.—**Ray Pierce**, Peoria, Ill.

Emergency tillage: The most common solution when vegetative cover is inadequate for wind erosion control. (PN-7149)

Leon Lyles is located at USDA-ARS, Wind Erosion Research, Dept. of Agronomy, Kansas State University, Manhattan, KS 66506. ■

Insect Rearing: Fighting Bugs With Bugs

Top: In the automated insect-rearing facility at the Corn Host Plant Resistance Research Unit, Mississippi State, MS, technicians Draka Elamin and Maggie Collier dispense freshly cooked diet into rearing cups at the rate of 75 cups per minute. First-instar lepidoptera larvae will then be added to the cups. (0285X0071-16)

Above: Thomas Oswalt, a technician at ARS' Mississippi State lab, harvests southwestern corn borer pupae from diet cups exactly 28 days from infestation. The rearing facility can produce 20,000 of these pupae per week. (0285X0069-30)

For thousands of years, people have maintained insects, such as honeybees and silkworms, for their useful products. Today, the art of raising insects—improved by science—has taken on added importance because of its critical role in controlling pests.

One major success story is the eradication of the screwworm from the United States, Puerto Rico, the Virgin Islands, and much of Mexico. ARS scientists developed a technology that takes advantage of the fact that a female screwworm mates only once and, when mated with a sterile male, lays eggs that do not hatch. USDA's Animal and Plant Health Inspection Service (APHIS) used the technology for rearing and releasing sterile male screwworm flies to eradicate this costly livestock pest. During peak production, the agency generated more than 500 million sterile males per week.

This is ARS's "number one accomplishment using the sterile male technique," says Ralph A. Bram, national program leader for research on insects affecting man and animals. It would not have been possible without the technology for mass rearing screwworms.

USDA's screwworm eradication campaign has since moved to southern Mexico. APHIS, ARS, and Mexican officials hope to eliminate the pest and create a permanent barrier near Panama within the next decade.

Scientists need precise numbers of insects at specific times to conduct useful experiments and validate results. Since natural insect attacks are unscheduled and uncontrolled, researchers started raising insects in artificial environments.

From its beginning as a simple hand operation more than 50 years ago, insect rearing has become a highly sophisticated and automated specialty, according to Robert D. Jackson, national program leader for entomology research. Through the years, entomologists have created special insect diets, developed automated production lines, and invented new equipment such as mechanical devices to form and fill feeding cups and special cages for egg laying. In doing this, they had to determine the chemical and physical conditions that affect growth and reproduction and learn how to prevent the spread of disease among the insects.

The Payoffs

After years of perfecting the rearing process, scientists can point to many valuable results. For example, because of repellents and insecticides developed from research involving artificially reared insects, people and animals are now protected from many diseases carried by fleas, flies, ticks, and cockroaches. And new methods to control plant-feeding insects are in use.

"Insect rearing has definitely helped the advancement of science," says E.F. Knipling, a pest management adviser for ARS's National Program Staff. "The ability to raise colonies of house flies has helped researchers discover many new insecticides and refine chemical formulations. Until appropriate insect colonies became available, important studies on insect physiology could not be undertaken, research on the genetics of economically important pests was handicapped, and the synthesis of sex pheromones was delayed.

"Today, insect rearing is a key technology in the search for alternatives to chemical insecticides and the creation of pest-resistant crops," Knipling maintains. "Biological control agents, including insects that destroy their own kind, are among the most promising ways to wage war on crop pests. New methods for rearing insect parasites and predators and propagating hosts for insect pathogens have made possible some of the most dramatic results."

Many Insects, Many Uses

This work goes on in more than 60 ARS rearing facilities around the country where hundreds of millions of insects are produced each year, Jackson notes. For instance:

• Each week in Gainesville, Fla., scientists rear a half-million mosquitoes, including those that can carry yellow fever and malaria, for ARS's animal and human disease studies. They also breed millions of house

flies, stable flies, cockroaches, and fire ants to develop and test repellents and other chemicals.

- When the need arises, scientists rear huge numbers of sterile male fruit flies to repel outbreaks of the pest, a major scourge for citrus producers and consumers. Researchers in Honolulu, Hawaii, produced 25 million sterile medflies each week to help subdue California's last big infestation. At the same time, Mexican researchers produce 700 million a week for use in their country.
- After more than a decade of work at Mississippi State, Miss., scientists developed new corn lines that withstand onslaughts of fall armyworms and southwestern corn borers. The resistance was discovered and selected by testing corn plants against laboratory-reared insects. When seed companies incorporate this resistance into new varieties, it will reduce crop losses by millions of dollars each year in the United States as well as in other parts of the world. (See "Insect-Resistant Corn Could Increase World Food," p. 10.)

In his search for biological control agents, entomologist Leslie C. Lewis of the Corn Insects Research Laboratory, Ankeny, IA, conducts bioassays of pathogens incorporated into the diet of European corn borers. Efficacy of the pathogens will later be field-tested. (1081X1350-4)

Lots of TLC

For successful rearing, insects need suitable food, physical environments, protection from enemies, and fit conditions for reproduction.

Their food can be natural, artificial, or a combination of both. But it must be readily available, inexpensive, and easily handled. Common ingredients in artificial diets include wheat germ, casein, brewer's yeast, fructose, honey, soybean flour, and cornmeal. Some insects, notably cockroaches, do well on ordinary dry dog food. Others thrive on baby food, pablum, or—in the case of mosquitoes—beef blood. Additives can range from vitamin and mineral supplements to sawdust.

Finding the most economical way to rear insects is as important as building suitable housing for them. Full knowledge of each insect and its life cycle, coupled with common sense, helps scientists hold down costs and streamline production.

All new facilities are designed to ensure that insects undergo only minor genetic changes. Major changes would reduce their ability to compete with native insects and predators in the wild, so rearing techniques are constantly refined to maintain insect quality.

Protecting insects from disease is a constant concern. Researchers at Beltsville, Md., for example, use stringent measures in their system for rearing tobacco hornworms—insatiable pests of vegetables. They clean utensils, equipment, walls, and floors with hospital antiseptics and use stainless-steel trays and other equipment that can be easily cleaned and sterilized. By limiting access to the rearing rooms, they reduce the chance of introducing diseases from the field. But just in case some pathogens do slip in, they include ingredients in the diet to prevent infection.

After a laboratory colony lays eggs, hatching soon occurs. At this point, the insects are fat, clumsy caterpillars, feeding in one place for hours on a doughlike artificial food. These caterpillars are turquoise, but in the wild they would be green from chlorophyll in their normal plant-based diet.

When the hornworms reach their next phase of life, technicians arrange the little mahogany-colored pupae in neat rows on the stainless-steel trays. These are stored in drawers where the pupae complete their inactive or resting stage and evolve into adults. After metamorphosis, the adult moths are kept in screened cages until they are needed for research.

Because the air is permeated with the moths' wing scales, scientists and technicians working in this area must wear face masks and special laboratory clothing. These coverings also

By the early 1960's, stunning successes in the eradication of screwworms by use of radioactive cobalt to sterilize male insects encouraged Hawaiian researchers to test the technique against tropical fruit flies in the Mariana Islands. With the sterile insect technique, which is still in use, insects lose their power to reproduce when bombarded by gamma rays from radioactive sources. If large enough numbers of sterile insects are released to overflood the natural population, the population collapses because of its inability to reproduce. (BN-22219)

limit the insects' exposure to diseases workers may carry into the area.

Throughout insect development, scientists use the latest knowledge to transform the indoor accommodation into the insect's natural environment, with optimal conditions for growth and reproduction. They use special rooms and growth chambers in which they can control such variables as light level, day length, temperature, and humidity. The chambers also provide standard conditions essential for studies of insect physiology and behavior.

Some insects are less hardy than others. The rearing process may start with thousands of eggs, but only a few hundred may survive to the final stage of a life cycle. If there are special requirements for an experiment, such as males only, the number available drops even further. Final data may be taken from just dozens of insects a week, depending on circumstances.

To safely and efficiently move insects from one location to another, entomologists often take advantage of the insects' inactive stages of life. Innovative packaging helps, too. For example, engineers in Tifton, Ga., adapted small plastic cups—normally used to serve jelly in restaurants—for use as shipping containers. An insect egg (or sometimes a small cluster) travels in each cup, accompanied by some artificial food. By the time a cup arrives at its destination, the egg has hatched and the young insect has begun feeding.

The Tifton scientists say their filler-capper machine lets them ship 10,000 1-ounce clear plastic cups a day. The type of species, of course, determines the number of insects that can travel in each container.

Fit conditions for reproduction are especially important. Each week a cotton geneticist at Mississippi State, Miss., receives a few thousand tobacco budworm pupae from a rearing facility in Stoneville, Miss. Under controlled conditions in his laboratory, these pupae turn into adults, mate, and lay eggs to produce the hundreds of thousands of newly emerged larvae needed for his tests.

Insect-Resistant Corn Could Increase World Food

Three new corn lines resistant to a number of destructive leaf eating and stalk boring insects are sparking excitement on the international scene. They hold promise for dramatically increasing corn production worldwide.

They were developed as sources of resistant germplasm through the team effort of plant breeder Paul Williams and entomologist Frank Davis, working with Gene Scott, research leader of the ARS Corn Host Plant Resistant Research Unit at Mississippi State, Miss. Last year, ARS and the Mississippi Agriculture and Forestry Experiment Station jointly released stocks of the corn to seed companies for commercial development.

According to Davis, "The value of these new corn plants is in their excellent resistance to the fall armyworm and southwestern corn borer in the United States and to other major stem borers throughout the world. This includes the European corn borer, which is a destructive pest in the United States as well as in Europe."

Davis, Williams, and Scott have been working toward insect-resistant corn for 16 years. Starting with mere traces of resistance, they gradually increased the level until the first significantly resistant new corn was released in 1974. Since then, the team has released eight lines, but the 1984 lines are far superior in resistance and yield characteristics, says Williams.

These lines are creating a lot of excitement internationally, Davis says. "We act as a clearinghouse for research data coming in from around the world. I just got a call from Mexico, and scientists we're working with at the International Center for the Improvement of Maize and Wheat are very excited about our lines' resistance to the sugarcane borer, a close relative of the southwestern corn borer."

Researchers from Kenya report that the new lines resist the African maize stem borer, and the lines tested in the Philippines resist the Asian corn borer. In fact, Davis says, the 1984 lines hold promise for producing crops that resist a broad spectrum of maize stem insects. These pests are a major factor limiting production in most of the world where corn is grown, including the entire continents of Africa and Asia.

Scientists from Turkey, Kenya, South Africa, Brazil, and other parts of the world have visited the laboratory at Mississippi State. Of particular interest to them is the automated rearing facility where Davis produces the millions of insects he and Williams need for identifying and developing resistant germplasm.

The research team's ultimate objective is to develop corn genetic

Mass Production—the New Norm

New rearing techniques contrast sharply with the old methods. At peak production, today's largely automated mass-rearing system for European corn borers in Ankeny, Iowa, provides researchers with more than a 157,000 pupae every 2 weeks. The process starts when female corn borers begin laying masses of eggs on wax paper that covers the top of oviposition (egg-laying) cages. Each day, technicians remove the papers and ship them to other laboratories that need corn borer larvae. This smooth-running, sophisticated operation represents the culmination of years of research on the means to raise many kind of insects in captivity. It was not always so routine.

"Years ago," says Jackson, "we collected the overwintering generation of European corn borers by harvesting infested cornstalks from fields during the winter and stacking them in outdoor cages until the moths emerged in the spring. That was okay for the first generation. But to get eggs for the second generation, in the summer we assembled scientists, graduate students, and workers around the farm, gave them sweep nets, and sent them into the fields to collect female moths to stock the oviposition cages. It was an expensive and unreliable system for obtaining egg masses for our studies," Jackson recalls. "But we had to use it until we could create an acceptable artificial diet to support a resident colony."

The contest between human beings and insects has gone on unremittingly for ages. But modern scientific technology has moved that contest to an entirely different plane. The most striking advances in insect control have come in the last 30 years. Considering the enormously successful results seen during this relatively brief period, we can realistically hope for even more dramatic achievements in the future.—**Sam Shaffer**, New Orleans, La., and **Peggy Adams**, formerly at Beltsville, Md.

Ralph A. Bram, Robert D. Jackson, and Edward B. Knipling are with USDA-ARS, National Program Staff, Bldg. 005, BARC-West, Beltsville, MD 20705. ■

A Primer for Rearing Insects

To fill the need for up-to-date information on the methods and materials, problems and solutions, and failures and successes of insect rearing as a scientific and commercial endeavor, ARS sponsored a special international conference to bring together leading experts in the field. As an outgrowth of that meeting, ARS has published a 306-page, illustrated handbook: *Advances and Challenges in Insect Rearing.* Copies of this publication can be purchased from the Superintendent of Documents, U.S. Government Printing Office, Washington, DC 20402.—**S.S.** ■

types with resistance levels that will substantially reduce or eliminate yield losses caused by these insect pests.

"In the South we have a long enough growing season for two corn crops," said Williams, "but disease and insect problems get in the way. Right now, an extra corn crop is not feasible because of the huge insect populations that build up in late summer, combined with southern corn rust problems. A second crop could be grown, certainly, but it would have to be grown under a virtual canopy of chemicals. What we want is a corn variety that will enable us to eliminate or greatly reduce spraying for pests."—**Bennett Carriere**, New Orleans, La.

Frank Davis is located at the Corn Host Plant Resistant Research Unit, P.O. Box 5367, Mississippi State, MS 39762; Paul Williams and Gene Scott are located at the Crop Science Research Laboratory, P.O. Box 5264, Mississippi State, MS 39762. ■

Above: Cutaway cornstalk reveals southwestern corn borer larvae, a major pest that costs farmers millions of dollars annually—particularly in irrigated corn-producing areas of the western high plains of Oklahoma and Texas. (0285X0066-28)

Left: Each of these healthy, insect-resistant corn plants was infested with 30 southwestern corn borer larvae 14 days earlier. Such heavy infestation of a nonresistant corn variety would kill the plants or severely reduce yield. (PN-7146)

Papayas Get Into Hot Water, Leave Hawaii

Hawaiian-grown papayas that have had a two-stage hot-water bath to eliminate fruit flies have been given the green light to enter the U.S. mainland. The first shipment left Hawaii in August 1984.

The treatment was developed as an alternative to fumigation with ethylene dibromide (EDB) which was banned last September as a fumigant for all fruits and vegetables in interstate commerce, except mangos that have been imported into the United States. ARS started the research 8 years ago in anticipation that EDB would be cancelled, says H.M. Couey, a plant physiologist and research leader with the Commodity Treatment, Handling, and Distribution Research Unit in Hilo, Hawaii.

The new treatment involves immersing fruit for 40 minutes in water at 108° F, followed by a 20-minute immersion in water at 120°. At the same time, fruits are selected based on their ripeness. ARS entomologist Stanley Seo at Honolulu, Hawaii, showed that papayas are free of fruit flies after treatment if less than one-quarter ripe.

Above: Papayas from Hawaii are treated in hot water tanks for fruit fly infestations and removed for cooling and packaging before shipment. (0385X193-4)

Left: Treatment supervisor Wilber Shimabukuro (left) and plant pathologist H. M. Couey at a papaya hot water treatment center near Hilo, Hawaii. (0385X193-11)

Couey says the hot-water treatment is based on a heat-distribution model developed by Charles Hayes, professor of physics at the University of Hawaii.

Fruit flies are among the most destructive insects to fruit and vegetable crops known. They include the Mediterranean and oriental fruit flies as well as the melon fly, all of which are present in Hawaii. Many insects, including fruit flies, are spread as larvae or eggs in fruits or vegetables shipped from infested areas.

"In the tests on commercial-sized lots of papayas, the treatment killed all eggs and 99 percent of the larvae," says Couey.

With respect to quality, Couey says, "In general, quality of the treated fruit has been excellent." Quality tests included flavor, texture, absence of scarring or pitting, and no increase in hard spots due to uneven ripening. Under commercial-scale conditions, however, hard spots have been showing up. Research is now underway that should soon eliminate or minimize this problem.

USDA's Animal and Plant Health Inspection Service approved the treatment for papayas shipped from Hawaii to the U.S. mainland and has submitted results of the tests to Japan's Ministry of Agriculture, Forestry, and Fisheries, Couey says. Japanese officials are now evaluating the data to determine if hot-water treated papayas will be admitted to their country.

Bob Souza of the Hawaii Papaya Administrative Committee estimates 1984 production at 7 million pounds with a value of $17 million. About 70 percent of the crop is shipped to the U.S. mainland and Canada, and 15 percent to Japan. The remaining 15 percent stays in Hawaii, he says.

According to Couey, the papaya industry has made a large investment to install equipment for the hot-water treatment. The first commercial system went into service in August.

The papaya research is only one of several projects underway in ARS to develop quarantine treatments to control fruit flies and other insects in agricultural crops. Other projects include work on methyl bromide; modified atmospheres alone or in combination of methods to kill insect eggs and mechanically remove fruits infested with larvae; and a systems approach that spans field production, storage, and packaging. This research is being conducted at Fresno, Calif; Yakima, Wash.; Weslaco, Tex.; and Gainesville and Miami, Fla.—**James Whorton**, Albany, Calif.

H.M. Couey is located at the Commodity Treatment, Handling, and Distribution Research Unit, P.O. Box 4459, Hilo, HI 96720. ■

Solar Heated Beehives

Solar homes for wintering honey bees may help colonies survive Wisconsin winters on about one-fifth less honey than that consumed in conventional hives.

ARS scientists working on the problem of maintaining bees in cold weather areas have designed a new translucent hive cover which lets warmth from the sun into the hive. The covers are made from white sheet plastic and cost about $5 each.

This information may be welcomed by beekeepers in a quandary over the economics of destroying colonies to avoid overwintering costs. Replacements, each spring, must be supplied with a new queen and package bees—an expensive process, says ARS entomologist Eric H. Erickson, Madison, Wis. The solar hive observations will be of interest to beekeepers who are sensitive to energy costs involved in taking bees south for winter, he says.

Now, beekeepers in northern states have another incentive for sheltering their bees at home—concern about the microscopic mite, *Acarapis woodi,* which arrived north of the Mexican border last summer. The mite hatches in bees' windpipes and sucks body fluids, impairing honey making and pollination. Infested colonies, weakened by the mite, may have trouble surviving cold winters.

When Erickson inspected the plastic-covered hives in midwinter he found bees almost uniformly distributed, but in hives that had not been covered, the bees were in a typical tight, winter cluster. Small tightly clustered populations sometimes starve as they fail to move from empty frames to honey-filled frames in a hive. The covers may help prevent this tragedy by serving as hive insulators and passive solar collectors, Erickson says.

Colonies in the 2-year study were well prepared, with large populations of young bees and with about 100 pounds of honey stores. Plastic hive covers are most beneficial to colonies entering winter less than ideally prepared, says Erickson.

After observing the condition of the hive covers at the end of the study, the researchers estimated they could have been used for 5 or even 10 years. The durability of the covers and the savings in unconsumed winter stores that they provide should make them economical to use, says Erickson.—**Ben Hardin,** Peoria, Ill.

Eric H. Erickson is located at the USDA-ARS, Bee Research Unit, 436 Russell Laboratories—Entomology, University of Wisconsin, Madison, WI 53706. ■

Above: Entomologist Eric H. Erickson installs his new solar bee cover. An entrance tube projecting from the cover allows the bees to come and go freely. (0185X0032-17)

Right: In cold weather, moisture condenses and freezes inside conventional hive cover. When the weather warms, the ice and frost will melt and soak the bees. Erickson's solar hive cover will help solve this overwintering problem. (0185X0032-7)

Technology Stretches Irrigation Water

A homeowner may look at wilted plants and haul out the garden hose, but ARS scientists water acres of plants without having to lift a finger.

A new solar-powered irrigation system does the job for them. Responding to commands from an internal computer, it automatically starts travelling along crop rows, metering out just enough water to satisfy thirsty plants.

Claude J. Phene at the Water Management Research Laboratory in Fresno, Calif., says the high-tech watering system was developed with one purpose in mind—to make scarce water go further in farming areas that depend on irrigation.

On some farms, computers are doing that to one degree or another. But the new system brings into play other technologies as well—from infrared thermometers and lasers to the solar cells that power the mobile system.

A computer starts and stops the system as it travels on wheeled towers along the rows. Water lines, suspended from a pipe between the towers, meter water to within inches of the plant rows. Along with the water, fertilizer, insecticide, and herbicide can be fed to plants at the same time.

Several state-of-the-art technologies ensure that plants get the right amount of water at exactly the right time.

Sensors monitor soil moisture and plant transpiration (water given off by the plant) to gauge exactly when plants need water. An automatic weather station records solar radiation, wind, air temperatures, and humidity. Infrared thermometers travel atop the towers to measure and record foliage temperatures. Foliage temperature is related to surrounding air temperature, humidity, and plant transpiration. All the various data inputs are fed into the system's computer which then determines the water needs of a crop. No human decision is required to start or stop watering.

Lasers guide the towers' moves, keeping the field towers perfectly aligned with the main tower that houses the system pump and filter.

Photovoltaic solar cells provide power for moving the towers over the field. Conventional electrical power is used now for pumping water, but photovoltaics could also be used for this purpose.

The system is a traveling trickle irrigation system—TTIS for short. It was originally designed mainly for research aimed at eliminating water wasted during crop irrigation. It has worked well for tomatoes and cotton in California test fields, Phene says *(See Agricultural Research, Sept. 1981.)*

Fed through a separate line, chemical pesticides are sprayed as a fine mist onto plants being watered simultaneously by the traveling trickle irrigation system (TTIS). Growth regulators, defoliants, and other agricultural chemicals can also be applied. (0684X892-20)

But Phene has expanded the system from an experimental machine pieced together to the current state-of-the-art irrigation system. Its basic component is a commercially built lateral-move irrigation system—one that travels along the rows in fields.

Presently available lateral-move systems cost about $550 per acre, based on a 250-acre system. He expects that the cost could decrease as more systems are used.

"TTIS might cost more initially than conventional lateral-move systems," he said. "However, the savings over the long run in valuable water, labor, and time may make it a workable system for farmers who must irrigate frequently." TTIS is "precise and fast in figuring out just how much water is needed," Phene said.

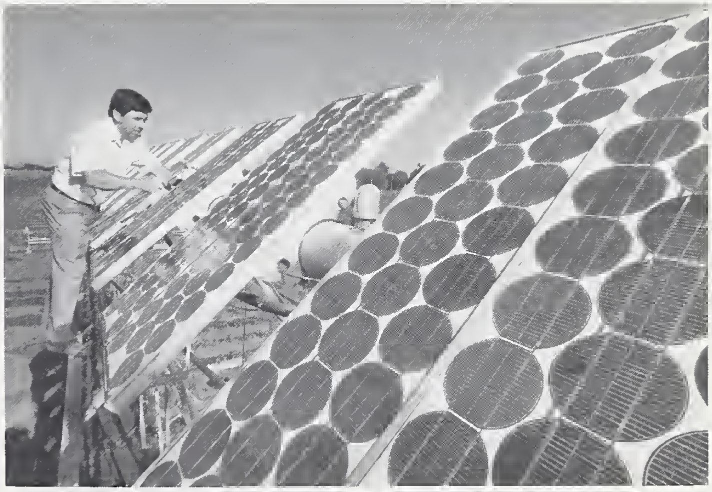
"It takes the guesswork and any human bias out of irrigating.

Phene says he will continue to test and perfect TTIS to improve on water use and placement. "In fact," he said, "TTIS, even now, is so efficient in placing water that even slightly saline water can be used for irrigating. We need to use every available drop of water, especially in the semiarid West."

Salt is a problem on 20 percent of the soils in the West, but by eliminating overirrigation, TTIS should help solve salinity problems caused by high water tables, Phene said.

Phene's research on TTIS is in cooperation with scientists at California State University at Fresno and the Center for Irrigation Technology.—**Hank Becker**, Beltsville, Md.

Claude J. Phene is located at the USDA-ARS, Water Management Laboratory, 2021 South Peach Ave., Fresno, CA 93727. ■



Top: Soil scientist Claude J. Phene adjusts speed control of TTIS as it moves over crop rows. (1083X1476-27)

Above: To improve energy efficiency, Claude J. Phene cleans solar panels that supply power to the TTIS towers. (0684X887-14)

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PATENTS

PATENTS is a regular feature of *Agricultural Research* magazine. Its purpose is to make the more than 1,200 patented inventions of the U.S. Department of Agriculture better known to businesses and individuals that might benefit from using them.

If you are interested in applying to obtain the license on a patent, write to the following address for an application form and information on license provisions and licensee responsibilities: Patents Office, USDA-ARS, Office of the Administrator, Rm. 323, Bldg. 003, Beltsville, MD 20705. ■

Clean Soil Sampling

A major improvement in soil sampling makes it possible to collect undisturbed and uncontaminated soil samples easily and at any depth. The apparatus, which works in tandem with commercial soil coring machinery, automatically shears off the outer cylinder (the contaminated portion) of the soil column as it is extruded from the tube.

From both an economic and environmental standpoint, the invention will facilitate the study of fertilizers, pesticides, and lime as they and their breakdown products move through the soil. It will also improve the quality of soil cores taken for engineering and construction needs.

The invention should be of interest to manufacturers of agricultural equipment in any country that practices intensive methods of modern agriculture. Investment capital is estimated at less than $10,000.

For further technical information, contact Julius Feldmesser, Rm. 154, Bldg. 011A, Beltsville Agricultural Research Center-West, Beltsville, MD 20705. *Patent Application Serial No. 637,241, "Soil Sampling Apparatus."* ■

Taking the Stick Out of Latex

Manufacturing products from natural and synthetic rubbers can be a sticky business. But a series of patented processes for encasing latex particles in a thin film of starch-based compounds results in a powdered latex that is nontacky and free-flowing.

The starch is in small enough amounts that it does not act as a filler. At quantities of less than 8 parts per 100 parts of latex solids, it has little effect on the properties of filled vulcanized rubber and only small effects on nonfilled rubber such as gum rubber.

Companies that manufacture tires and other rubber products will want to learn more about these patents.

For further information, contact Thomas P. Abbott, Northern Regional Research Center, 1815 N. University, Peoria, IL 61604. *Patent No. 3,941,767, "Method of Preparing Powdered Elastomer Compositions,"* and related *Patent Nos. 3,830,762; 3,442,832; 3,480,572; 3,645,940; 3,673,136; and 3,714,087.* ■

Temperature-Adaptive Textiles

Fibers, yarns, and fabrics can now be effectively treated with materials that store heat when the temperature rises and release heat when the temperature drops. In some cases, the textiles can absorb or release up to four times as much heat as ordinary fibers through as many as 150 heating and cooling cycles.

Modified textiles made from these fibers could be used in cold-weather clothing, building insulation, and a variety of materials to protect animals, plants, and food from wide swings in temperature. (See *Agricultural Research,* July/Aug. 1984, p. 6)

The textiles are produced by dissolving phase-change or plastic crystalline materials in a solvent such as water and then filling hollow fibers or impregnating nonhollow fibers with the solution. Phase-change materials store and release heat when they change from a solid to a liquid and vice versa. Plastic crystals, on the other hand, can undergo large changes in heat content while remaining in the solid phase.

For more technical information, contact Tyrone L. Vigo, Textiles and Clothing Research Laboratory, 1303 W. Cumberland Ave., Knoxville, TN 37916. *Patent Application Serial No. 626,850, "Process for Rendering Hollow Textile Fibers Temperature-Adaptable to Various Thermal Environments."* ■